CLOUD COMPUTING

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ABSTRACT

A concrete mass of technology experts and stakeholders participating in the fourth Future of the Internet survey suppose that by 2020 most people will access software applications online and share and access information through the use of remote server networks, rather than depending primarily on tools and information housed on their individual, personal computers. They say that ***Cloud Computing*** *will become more dominant than the desktop in the next decade. In other words, most users will perform most computing and communicating activities through connections to servers operated by outside firms.*

This does not mean, however, that most of these experts think the desktop computer will disappear soon. The majority sees a hybrid life in the next decade, as some computing functions move towards the ***Cloud*** *and others remain based on personal computers.*

By 2020, most people won't do their work with software running on a general-purpose PC. Instead, they will work in Internet-based applications such as Google Docs, and in applications run from smart phones. Aspiring application developers will develop for smart phone vendors and companies that provide Internet-based applications.

The aim of this paper is to clarify terms, provide the comparisons between cloud and conventional Computing, and identify the top technical and non-technical obstacles and opportunities of Cloud Computing.

INTRODUCTION

Cloud computing is a technology that uses the internet and central remote servers to maintain data and applications. Cloud computing allows consumers and businesses to use applications without installation and access their personal files at any computer with internet access. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth. Cloud computing is Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid. Cloud computing describes a new supplement, consumption, and delivery model for IT services based on the Internet, and it typically involves over-the-Internet provision of dynamically scalable and often virtualized resources. Typical cloud computing providers deliver common business applications online that are accessed from another Web service or software like a Web browser, while the software and data are stored on servers. A simple example of cloud computing is Yahoo email or Gmail etc. You don’t need software or a server to use them. All a consumer would need is just an internet connection and you can start sending emails.

Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service (SaaS). The datacenter hardware and software is what we will call a Cloud. When a Cloud is made available in a pay-as-you-go manner to the general public, we call it a Public Cloud; the service being sold is Utility Computing.We use the term Private Cloud to refer to internal datacenters of a business or other organization, not made available to the general public. Cloud Computing is the sum of SaaS and Utility Computing.

From a hardware point of view, three aspects are new in Cloud Computing.

1. The illusion of infinite computing resources available on demand, thereby eliminating the need for Cloud computing users to plan far ahead for provisioning.

2. The elimination of an up-front commitment by Cloud users, thereby allowing companies to start small and increase hardware resources only when there is an increase in their needs.

3. The ability to pay for use of computing resources on a short-term basis as needed (e.g., processors by the hour and storage by the day) and release them as needed, thereby satisfying conservation by leasing machines and storage go when they are no longer useful.

TYPES OF CLOUDS

Public cloud

Public cloud or external cloud describes cloud computing in the traditional mainstream sense, whereby resources are dynamically provisioned on a fine-grained, self-service basis over the Internet, via web applications/web services, from an off-site third-party provider who and bills on a fine-grained utility computing basis.

Community cloud

A community cloud may be established where several organizations have similar requirements and look for to share infrastructure so as to realize some of the benefits of cloud computing. With the costs spread over fewer users than a public cloud (but more than a single tenant) this option is more expensive but may offer a higher level of privacy, security and/or policy compliance. Examples of community cloud include Google's "Gov Cloud".

Hybrid cloud

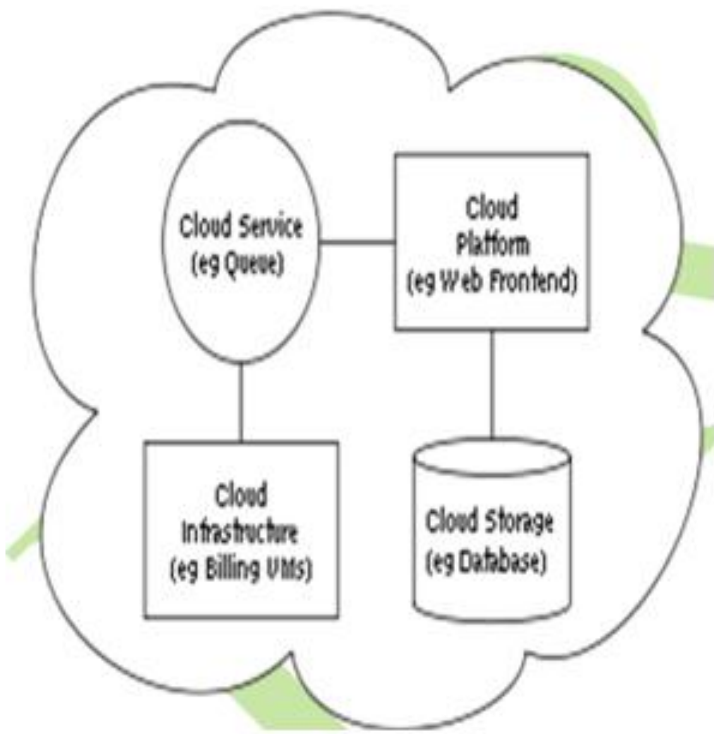
A hybrid cloud environment consisting of multiple internal and/or external providers will be typical for most enterprises. By integrating multiple cloud services users may be able to ease the transition to public cloud services while avoiding issues such as PCI compliance. Another perspective on deploying a web application in the cloud is using Hybrid Web Hosting, where the hosting infrastructure is a mix between Cloud Hosting for the web server, and Managed dedicated server for the database server.

Private cloud

The concept of a Private Computer Utility was first described by Douglas Parkhill in his 1966 book "The Challenge of the Computer Utility". The idea was based upon direct comparison with other industries (e.g. the electricity industry) and the extensive use of hybrid supply models to balance and diminish risks.

Private cloud and internal cloud have been described as neologisms, however the concepts itself pre-dates the term cloud by 40 years. Even within modern utility industries, hybrid models still exist despite the formation of reasonably well functioning markets and the ability to combine multiple providers.

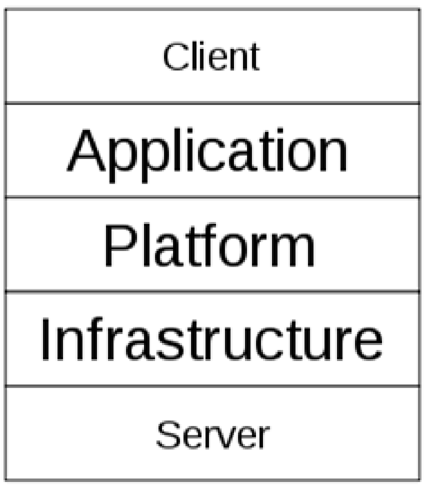
ARCHITECTURE FOR CLOUD COMPUTING



CLOUD COMPUTING MODEL ARCHITECTURE

Cloud architecture, the systems architecture of the software systems involved in the delivery of cloud computing, typically involves multiple cloud components communicating with each other over application programming interfaces, usually web services. This resembles Unix philosophy of having multiple programs each doing one thing well and working together over universal interfaces. Complexity is controlled and the resulting systems are more manageable than their huge counterparts. The two most significant components of cloud computing architecture are known as the front end and the back end. The front end is the part seen by the client, i.e. the computer user. This includes the client's network (or computer) and the applications used to access the cloud via a user interface such as Internet Explorer. The back end of the cloud computing architecture is the „cloud" itself, comprising various computers, servers and data storage devices.

LAYERS OF CLOUD COMPUTING



Client

A cloud client consists of computer hardware and/or computer software that relies on cloud computing for application delivery, or that is specifically designed for delivery of cloud services and that, in either case, is essentially useless without it. Examples include some computers, phones and other devices, operating systems and browsers.

Application: It's all On Demand

Cloud application services or "Software as a Service (SaaS)" deliver software as a service over the Internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support. By running business applications over the internet from centralized servers rather than from on-site servers, companies can cut some serious costs. Furthermore, while avoiding maintenance costs, licensing costs and the costs of the hardware required to run servers on-site, companies are able to run applications much moreefficiently from a computing standpoint.

Key characteristics include:

- Network-based access to, and management of, commercially available software
- Activities that are managed from central locations rather than at each customer's site, enabling customers to access applications remotely via the Web
- Application delivery that typically is closer to a one-to-many model (single instance, multi-tenant architecture) than to a one-to-one model, including architecture, pricing, partnering, and management characteristics
- Centralized feature updating, which obviates the need for downloadable patches and upgrades.
- **Who is offering on Demand Software? -** The companies below are already established in the On-Demand software or SaaS business. These companies charge their customers a subscription fee and in return host software on central servers that are accessed by the end user via the internet.
  - Salesforce.com (CRM)
  - Google (GOOG)
  - NetSuite (N)
  - Taleo (TLEO)
  - Concur Technologies (CNQR)
  - Info Technologies (IT)
  - canadasoftware.net (nexgen)

Platforms:

Many of the companies that started out providing On Demand application services have developed platform services as well. The platform segment of cloud computing refers to products that are used to deploy internet. NetSuite, Amazon, Google, and Microsoft have also developed platforms that allow users to access applications from centralized servers. Cloud platform services or "Platform as a Service (PaaS)" deliver a computing platform and/or solution stack as a service, often consuming cloud infrastructure and supporting cloud applications. It facilitates use of applications without the cost and complexity of buying and managing the essential hardware and software layers.

Infrastructure

Cloud infrastructure services or "Infrastructure as a Service (IaaS)" delivers computer infrastructure, typically a platform virtualization environment as a service. Rather than purchasing servers, software, data center space or network equipment, clients instead buy those resources as a fully outsourced service. The service is typically payable on a utility computing basis and amount of resources consumed (and therefore the cost) will typically reflect the level of activity. It is an evolution of virtual private server offerings.

Server

The server's layer consists of computer hardware and/or computer software products that are specifically designed for the delivery of cloud services, including multi-core processors, cloud-specific operating systems and combined offerings.

Key features

- **Agility** improves with users' ability to rapidly and inexpensively re-provision technological infrastructure resources.
- **Cost** is claimed to be greatly reduced and capital expenditure is converted to operational expenditure. This apparently lowers barriers to entry, as infrastructure is typically provided by a third-party and does not need to be purchased for one-time or rare demanding computing tasks. Pricing on a utility computing basis is fine-grained with usage-based options and fewer IT skills are required for implementation (in-house).
- **Device and location independence** enable users to access systems using a web browser regardless of their location or what device they are using (e.g., PC, mobile). As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can connect from anywhere.
- **Multi-tenancy** enables sharing of resources and costs across a large group of users thus allowing for:
    - **Centralization** of infrastructure in locations with lower costs (such as real estate, electricity, etc.)
    - **Peak-load capacity** increases (users need not engineer for highest possible load-levels)
    - **Utilization and efficiency** improvements for systems that are often only 10–20% utilized.

- **Reliability** is improved if multiple unnecessary sites are used, which makes well designed cloud computing suitable for business stability and disaster recovery. Nonetheless, many major cloud computing services have suffered outages, and IT and business managers can at times do little when they are affected.

- **Scalability** via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis near real-time, without users having to engineer for peak loads. Performance is monitored, and consistent and loosely coupled architectures are constructed using web services as the system interface.

- **Security** could improve due to centralization of data, increased security-focused resources, etc., but concerns can persevere about loss of control over certain sensitive data, and the lack of security for stored kernels. Security is often as good as or better than under traditional systems, in part because providers are able to devote resources to solving security issues that many customers cannot afford. Providers typically keep a record of accesses, but accessing the audit records themselves can be difficult or impossible. Furthermore, the complexity of security is greatly increased when data is distributed over a wider area and / or number of devices.

- **Maintenance** cloud computing applications are easier to maintain, since they don't have to be installed on each user's computer. They are easier to support and to improve since the changes reach the clients instantly.

- **Metering** cloud computing resources usage should be measurable and should be metered per client and application on daily, weekly, monthly, and annual basis. This will permit clients on choosing the vendor cloud on cost and reliability.

NEW TECHNOLOGY TRENDS AND BUSINESS MODELS

Accompanying the emergence of Web 2.0 was a shift from "high-touch, high-margin, high-commitment" provisioning of service "low-touch, low-margin, low-commitment" self-service. For example, in Web 1.0, accepting credit card payments from strangers required a contractual arrangement with a payment processing service such as VeriSign or Authorize.net; the arrangement was part of a larger business relationship, making it time-consuming for an individual or a very small business to accept credit cards online. With the emergence of PayPal, however, any individual can accept credit card payments with no contract, no long-term commitment, and only modest pay-as-you-go transaction fees. The level of "touch" (customer support and relationship management) provided by these services is minimal to nonexistent, but the fact that the services are now within reach of individuals seems to make this less important. Similarly, individual's "Web pages can now use Google AdSense to realize revenue from ads, rather than setting up a relationship with an ad placement company, such DoubleClick (now acquired by Google). Those ads can provide the business model for Wed 2.0 apps as well. Individuals can distribute Web content using Amazon Cloud Front rather than establishing a relationship with a content distributionnetwork such as Akamai. Amazon Web Services capitalized on this insight in 2006 by providing pay-as-you-go computing with no contract: all customers need is a credit card. A second innovationwas selling hardware-level virtual machines cycles, allowing customers to choose their own software stack without disturbing each other while sharing the same hardware and thereby loweringcosts further.

NEW APPLICATION OPPORTUNITIES

While we have yet to see fundamentally new types of applications enabled by Cloud Computing, we believe that several important classes of existing applications will become even more realistic with Cloud Computing and contribute further to its momentum. When Jim Gray examined technological trends in 2003, he concluded that economic necessity mandates putting the data near the application, since the cost of wide-area networking has fallen more slowly (and remains relatively higher) than all other IT hardware costs. Although hardware costs have changed since Gray's analysis, his idea of this "breakeven point" has not. We use Gray's insight in examining what kinds of applications represent particularly good opportunities and drivers for Cloud Computing.

Mobile interactive applications. Tim O "Reilly believes that "the future belongs to services that respond in real time to information provided either by their users or by nonhuman sensors." Such services will be attracted to the cloud not only because they must be highly available, but also because these services generally rely on large data sets that are most conveniently hosted in large datacenters. This is especially the case for services that combine two or more data sources or other services, e.g., mashups. While not all mobile devices enjoy connectivity to the cloud 100% of the time, the challenge of disconnected operation has been addressed successfully in specific application domains, so we do not see this as a significant obstacle to the appeal of mobile applications.

Parallel Batch Processing. Although thus far we have concentrated on using Cloud Computing for interactive SaaS, Cloud Computing presents a unique opportunity for batch-processing and analytics jobs that analyze terabytes of data and can take hours to finish. If there is enough data parallelism in the application, users can take advantage of the cloud's new "cost associativity": using hundreds of computers for a short time costs the same as using a few computers for a long time. Clouder is pursuing commercial opportunities in this space. Again, using Gray's insight, the cost/benefit analysis must weigh the cost of moving large datasets into the cloud against the benefit of potential speedup in the data analysis. When we return to economic models later, we consider that part of Amazon's motivation to host large public datasets for free may be moderate to the cost of this analysis and thereby attract users to purchase Cloud Computing cycles near this data.

The rise of analytic. A special case of compute-intensive batch processing is business analytics. While the large database industry was originally dominated by transaction processing, that demand is leveling off. A growing share of computing resources is now spent on understanding customers, supply chains, buying habits, ranking, and so on. Hence, while online transaction volumes will continue to grow slowly, decision support is growing rapidly, shifting the resource balance in database processing from transactions to business analytics.

Extension of compute-intensive desktop applications. The latest versions of the mathematics software packages Matlab and Mathematica are capable of using Cloud Computing to perform expensive evaluations. Other desktop applications might similarly benet from seamless extension into the cloud. Again, a reasonable test is comparing the cost of computing in the Cloud plus the cost of moving data in and out of the Cloud to the time savings from using the Cloud. Symbolic mathematics involves a great deal of computing per unit of data, making it a domain worth investigating. An interesting alternative model might be to keep the data in the cloud and rely on having sufficient bandwidth to enable suitable visualization and a responsive GUI back to the human user. Offline image rendering or 3D animation might be a similar example: given a compact description of the objects in a 3D scene and the characteristics of the lighting sources, rendering the image is an embarrassingly parallel task with a high computation-to-bytes ratio.

"Earthbound" applications. Some applications that would otherwise be good candidates for the cloud's elasticity and parallelism may be let down by data movement costs, the fundamental latency limits of getting into and out of the cloud, or both. For example, while the analytics associated with making long-term financial decisions are appropriate for the Cloud, stock trading that requires microsecond precision is not. Until the cost (and possibly latency) of wide area data transfer decrease, such applications may be less obvious candidates for the cloud.

RESEARCH

A number of universities, vendors and government organizations are investing in research around the topic of cloud computing. Academic institutions include University of Melbourne (Australia), Georgia Tech, Yale, Wayne State, Virginia Tech, University of Wisconsin Madison, Boston University, Carnegie Mellon, MIT, Indiana University, University of Massachusetts, University of Maryland, North Carolina State, Purdue, University of California, University of Washington, University of Virginia, University of Utah, University of Minnesota, among others . In July 2008, HP, Intel Corporation and Yahoo! Announced the creation of a global, multi-data center, open source test bed, called Open Cirrus, designed to encourage research into all aspects of cloud computing, service and data center management. In July 2010, HP Labs India announced a new cloud-based technology designed to simplify taking content and making it mobile-enabled, even from low-end devices. Called Siteon Mobile, the new technology is designed for emerging markets where people are more likely to access the internet via mobile phones rather than computers.

CONCLUSION

Cloud computing comes into focus only when you think about what IT always needs: a way to increase capacity or add capabilities on the fly without investing in new infrastructure, training new personnel, or licensing new software. Cloud computing encompasses any subscription-based or pay-per-use service that, in real time over the Internet, extends its existing capabilities. Cloud computing is at an early stage, with a motley crew of providers large and small delivering a slew of cloud-based services, from full-blown applications to storage services to spam filtering. Yes, utility-style infrastructure providers are part of the mix, but so are SaaS (software as a service) providers such as Salesforce.com. Today, for the most part, IT must plug into cloud-based services individually, but cloud computing aggregators and integrators are already emerging.

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